

SUPPORT FOR AMENDMENTS

The claims have been amended for clarity. Claims 11-17 have been newly added. Support for the amendments and new claims can be found in the claims as originally filed and in the specification:

- Claim 1: page 2, lines 17-18; & page 4, lines 7-13; & Examples 1 & 2;
- Claims 3 & 4: page 5, lines 19-23;
- Claim 5: page 4, line 14 – page 5, line 5;
- Claim 6: page 5, lines 6-11;
- Claim 7: page 6, lines 8-11;
- Claim 9: page 2, line 25 – page 3, line 12;
- Claim 10: page 2, lines 21-24; page 4, lines 3-6; & original Claim 10;
- Claim 11: page 2, lines 18-20;
- Claim 12: page 6, lines 11-24;
- Claims 13 & 15: Example 1; and
- Claims 14, 16, & 17: Example 2

No new matter has been added.

REMARKS/ARGUMENTS

The present claims relate to processes for the disposal of sulfur. The processes include transforming elemental sulfur into at least one liquid state sulfane having the formula H_2S_{n+1} , where n is a number from 1 to 7. The processes also include injecting the at least one liquid state sulfane at room temperature into a geological formation having a temperature of from room temperature to 150°C.

The rejection of Claims 1-3 and 10 under 35 U.S.C. § 103(a) in view of U.S. Patent 3,920,424 (Estep et al.) in view of U.S. Patent 4,773,483 (Paul) is respectfully traversed. These cited references disclose methods where sulfanes (or sulfides) are broken down to H₂S and elemental sulfur (in molten or precipitated form). In contrast, elemental sulfur *is transformed into sulfanes* during the presently claimed processes. This transformation is the opposite of what is disclosed in the cited references. The presently claimed processes form sulfanes because sulfur in the form of sulfanes can be more easily stored than elemental sulfur or H₂S (see page 3, lines 5-12 of the specification as filed).

Estep et al. discloses processes where hydrogen polysulfides (H₂S_x) are **removed** from molten sulfur. Here, the hydrogen polysulfides present in the molten sulfur are considered to be impurities (Col. 1: 27-28) and are thus removed by conversion to H₂S and elemental sulfur. Even though this reference discloses an equilibrium reaction between hydrogen polysulfides and H₂S gas and sulfur, the disclosure of the reference is directed towards the forward reaction where **sulfanes are broken down to form** H₂S gas and liquid sulfur:

By the practice of this invention **the equilibrium** between hydrogen polysulphide, hydrogen sulphide and liquid sulphur **is shifted** and the hydrogen polysulphides will decompose to form hydrogen sulphide and liquid sulphur as follows: H₂S_x (liquid) \rightleftharpoons H₂S ↑ (gas) + (X-1)S (liquid).

See Col. 2: 50-56 of Estep et al. See also, *e.g.*, Col. 1: 65 – Col. 2: 2 & Col. 3: 35–39.

Instead of removing sulfanes dissolved in molten sulfur as is disclosed in Estep et al., at least one liquid state sulfane (polysulfides) having the formula H₂S_{n+1} (where n = 1 to 7 – see Claims 1 & 5) **is formed** during the presently claimed processes by the conversion of sulfur (in the form of H₂S). This reaction is the opposite of what is disclosed in Estep et al. The at least one liquid state sulfane is formed during the presently claimed processes because it can be stored in a geological formation having a temperature ranging from room

temperature to 150°C (see Claim 1). Sulfanes rather than molten sulfur are stored in this geological formation having these temperatures because:

if molten sulfur in the pure state were pumped [into the geological formation], this would immediately solidify causing the obstruction of the pumps and pipe-lines.

See page 3, lines 8-12 of the specification as filed. Estep et al. clearly discloses that the sulfur is maintained in the molten state (see, *e.g.* Col. 2: 62–65).

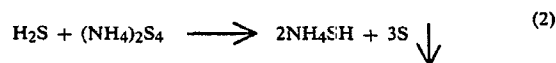
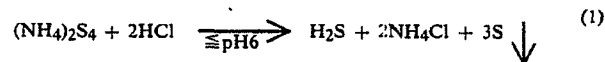
Furthermore, injecting the at least one liquid state sulfane into the geological formation is energetically preferred over the injecting of molten sulfur. The at least one liquid state sulfane of the presently claimed processes can have viscosities ranging from 0.616 to 11.1 CPoise at 20°C (see Claim 12), and in preferred embodiments, the at least one liquid state sulfane can have viscosities of 1.84 and 3.64 CPoise (see Claims 13 and 14). These viscosities are lower than the viscosity of molten sulfur (12 CPoise – see page 10, lines 15-17 of specification as filed), and as a result, less energy is required to pump and inject the at least one liquid state sulfane rather than molten sulfur:

Sulfur in the molten state has a viscosity of about 12 CPoise, which is almost 7 times higher than the mixture of sulfanes. From an energy point of view, it is consequently more convenient to pump sulfur in the form of sulfane rather than in the molten state.

See page 9, lines 2-6 of the present specification. As noted above, Estep et al. discloses the purification of molten sulfur. Injecting the molten sulfur of Estep et al. during the presently claimed processes would be energetically unfavorable (see above quote). Thus, one of ordinary skill in the art would not be motivated by the disclosure of Estep et al. to use molten sulfur during the injecting of the presently claimed processes.

Therefore, the presently claimed processes would not be suggested to one of ordinary skill in the art by the disclosure of Estep et al. because: (1) the cited reference discloses high temperature processes where sulfanes are decomposed during the purification of molten sulfur; (2) molten sulfur would cool and solidify when injected and stored in a geological formation used during the present invention; (3) the solidifying of the molten sulfur would result in blocking the pumps and pipes that are used during the injecting of the presently claimed processes; and (4) the viscosity of molten sulfur is too high and thus requires more energy to inject compared to the at least one liquid state sulfane used in the presently claimed processes. Thus, this cited reference cannot affect the patentability of the present claims.

In regard to Paul, this cited reference also discloses the formation of H₂S and elemental sulfur but by reacting sulfides (*e.g.* (NH₄)₂S₄) with an acid:



See Col. 3: 51-58 of Paul. Here, elemental sulfur is precipitated in highly permeable zones of subterranean oil containing formations to form deposits which plug these zones:

This invention relates to a method for improving the vertical and/or horizontal sweep efficiency of a subterranean oil-containing formation ... by ... injecting an aqueous solution of polysulfides that disproportionates under the pH conditions ... to form a precipitate of elemental sulfur in situ which plugs the relatively highly permeable zones.

See Col. 1: 7-18 of Paul (emphasis added) and the Abstract. As noted in the discussion about Estep et al., above, the effect of forming solid sulfur is adverse the present invention and Paul admits that precipitated sulfur is used as a plugging agent (see above quote).

Furthermore, in an additional embodiment of the presently claimed processes, elemental sulfur can be dissolved (*i.e.* not precipitated) in sulfanes produced by the presently claimed processes:

In another embodiment it is possible to use synthesized sulfanes as a solvent for dissolving additional elemental sulfur, in order to reduce the quantity of sulfur to be converted into sulfanes for its elimination.

See page 2, lines 21-24 of present specification (emphasis added) and Claim 10. Indeed, this additional aspect of the presently claimed invention is opposite to what is disclosed in Paul.

Therefore, the disclosure of Paul would not suggest to one of ordinary skill in the art the presently claimed processes because: (1) sulfanes (or sulfides) are reacted, not formed, and (2) elemental sulfur is precipitated and acts a plugging agent. Both of these aspects are adverse to the present invention. Thus, this cited reference cannot affect the patentability of the present claims.

Likewise, the combined disclosures of Estep et al. and Paul would not suggest to one of ordinary skill in the art the presently claimed inventions because both cited references disclose breaking down sulfanes (rather than forming sulfanes) and the references disclose the formation and purification of elemental sulfur (discussed above). In contrast, the present invention relates to the formation of sulfanes and the precipitation or solidifying of elemental sulfur is adverse to the present invention (discussed above). Thus, the combined disclosures of the cited references cannot affect the patentability of the present claims.

Accordingly, the rejection should be withdrawn.

The rejection of Claim 4 under 35 U.S.C. § 103(a) in view of Estep et al., Paul, and U.S. Patent 4, 966,736 (Harbolt et al.) is respectfully traversed for the same reasons given above. Accordingly, the rejection should be withdrawn.

The rejection of Claim 7 under 35 U.S.C. § 103(a) in view of Estep et al. and *Journal of Fluid Mechanics*, 2002, 461, 51-60 (Swanson et al.) is respectfully traversed for the same reasons given above. Accordingly, the rejection should be withdrawn.

The rejection of Claim 8 under 35 U.S.C. § 103(a) in view of Estep et al., Paul, and U.S. Patent Application Publication 2007/0193939 (Hawes et al.) is respectfully traversed for the same reasons given above. Accordingly, the rejection should be withdrawn.

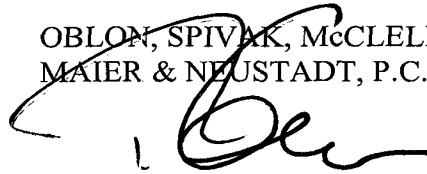
The rejection of Claim 9 under 35 U.S.C. § 103(a) in view of Estep et al., Paul, and *Ind. Eng. Chem. Res.* 1996, 35, 1257-1262 (Winter et al.) is respectfully traversed for the same reasons given above. Accordingly, the rejection should be withdrawn.

The rejection of Claims 6-7 under 35 U.S.C. § 112, 2nd ¶, has been obviated by amendment. Accordingly, the rejection should be withdrawn.

Applicants respectfully submit that the present application is in condition for allowance. Notification thereof is requested.

Respectfully submitted,

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